A Beginner's Guide to GNSS in Europe

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A. GNSS (Global Navigation Satellite System)

1. Setting the scene

This paper was prepared by EVP Europe in order to provide an overview of what is currently going in the field of Satellite Navigation and also what the future holds in terms of ATC. *A Beginner's Guide to GNSS in Europe* was written to help IFATCA representatives have clearer picture of the actual situation and it was the intent of the author that this document is a living one and that IFATCA Standing Committee 1 be able to use it in their work. I have submitted this paper to the Swiss specialist on Satellite Navigation to ensure accuracy. Dr. Scaramuzza has done his thesis on the DGPS trials by Crossair into a Swiss Airport (Lugano, mountainous region) and has wide knowledge in this field.

For centuries, we have turned to the heavens for guidance. The stars provided a reliable source of navigation information for the early explorers and sailors who ventured into unknown worlds beyond the horizon.
Today, the heavens offer a new means to navigate with a precision that early adventurers could only dream of. This is satellite navigation: using data transmitted by Earth-orbiting spacecraft to pinpoint the location of aircraft, ships and trucks, along with a host of other applications, to an accuracy of metres.
Since the introduction of satellite navigation in the 1970s, applications for the high-precision positioning data have grown beyond all expectations. Today, millions of small portable receivers capable of receiving the satellite signal are being sold annually.

Existing systems under national control:

Two main satellite-based navigation systems are operational today. The USA's Global Positioning System (GPS) and Russia's GLObal NAvigation Satellite System (GLONASS). Both are military networks, each based on constellations of 24 operational satellites. Civilian applications always were expected for GPS and GLONASS despite their military origins. However, non-military utilisation of the systems has grown far beyond what was originally envisaged. It is estimated that nine out of every ten new satellite navigation receivers currently sold are for civilian or commercial use.

The current systems are thus widely used by civilians: hikers, private pilots and boat owners are already making extensive use of satellite positioning. Land and offshore surveyors have been using GPS for over 10 years, and they probably have more experience than any other civil user group. Oil and gas recovery offshore is completely dependent on accurate navigation and positioning. The rate at which new gas and oil finds are made is in exact relationship to the accuracy with which seismic exploration vessels can operate. In agriculture the precise distribution of fertilisers is already being performed using satellite position reporting systems.

Military applications were at the origins of the American GPS and the Russian GLONASS, and the satellites continue to serve their original masters. In addition to the obvious defence uses, there are many other military requirements for precision positioning. The Allied Air Force was guided by satellite navigation for their food and supply airdrops to civilians in besieged sections of the former Yugoslavia during the region's long civil war. Disputed borders are pinpointed using satellite position data. Search and rescue missions are routinely being performed with higher accuracy.

Satellite navigation will completely change the lives of some people: reaching from the electronic dog to provide guidance to blind people to the car navigation and traffic management systems based on satellite navigation. And in the civil aviation sector from offer of shorter routes, quicker access to airports and final approaches and landing at most airports according to CAT 1 requirements. Precision approaches CAT3 will probably not arrive before the year 2010.

2. CNS/ATM[1]

CNS/ATM as defined by ICAO is "Communications, Navigation and Surveillance systems, employing digital technologies, including satellite systems together with various levels of automation, applied in support of a seamless global Air Traffic Management system." There is no unique CNS /ATM solution; there are a variety of CNS/ATM – related implementations, which all contribute to the CNS/ATM global goal. The challenge is to define an implementation that allows benefits and return on investment to be achieved as rapidly as possible. In the near-term this is best achieved by looking at the CNS/ATM elements using two simple constraints: what exists now and what is likely to exist over the next years.

Communications for CNS/ATM is digital-based and data link is an augmentation of voice communications for the next five years. Terrestrial-based VHF Data Link (VDL) is well suited for the en-route, terminal and airport area where line-of-sight systems can be used. VDL is used today for ATM functions such as Pre-Departure Clearance (PDC), Departure Clearance (DCL), Digital Automatic Terminal Information Service (D-ATIS), Terminal Weather Information for Pilots (TWIP) and other ATM functions. Satellite and HF data links are more suitable for oceanic and remote areas where VDL is not available. Satellite and HF will continue to be provided by private service providers whereas private service providers or other authorities may supply VDL.

Area navigation (RNAV) capability allows Air Navigation Service Providers (ANSPs) to offer the most cost-effective solutions to airspace users. GNSS support highly accurate RNAV (*sic. almost*) [2]everywhere, including over the oceans and in remote areas. GNSS avionics are relatively inexpensive, so all levels of users can participate in RNAV operations, thus allowing ANSPs to structure airspace for maximum capacity. GNSS also gives airspace designers a future option in developing procedures that support low minima, avoid noise sensitive areas and reduce flying time in the terminal area (4D NAV).

Ultimately, GNSS could replace all traditional aids, although there are still technical, operational and institutional issues to be resolved before reaching this goal. Core navigation satellites, GPS and GLONASS, are already in service with many operators using GPS for en-route through non-precision approach operations. A "sole means" GNSS environment requires ANSPs to field Satellite-Based and Ground- Based Augmentation Systems (SBAS and GBAS). SBAS and GBAS that meet ICAO standards will become operational within the 5-year period.

Over the next 5 years and longer it is expected that both primary and secondary radar will continue to be used, supplemented by Mode S data link where appropriate. Remote and oceanic areas will see increased use of Automatic Dependent Surveillance (ADS) to supplement and eventually replace today's voice-based position reporting in procedural airspace.

The airframe manufacturers, Airbus and Boeing, market their near-term implementations of CNS/ATM as FANS Avionics packages. Airbus advertises the FANS-A; Boeing advertises the FANS-1. FANS-1/A is an initial implementation of CNS /ATM, which provides a subset of the ICAO-defined ADS and CPDLC functions over the existing VHF and satellite ACARS (Aircraft Communications, Addressing and Reporting System) data links. It is designed to allow airlines to achieve earlier benefits of the CNS/ATM environment.

Note the IFATCA policy: FANS-1/A CPDLC has limitations. Further these shortcomings must preclude further proliferation of this technology, into states of the world where it is not currently deployed. Once the Aeronautical Telecommunications Network (ATN) Datalink system is deployed, use of the FANS-1/A CPDLC shall be replaced by the ATN system and FANS-1/A systems shall not be accommodated in the ATN, as this would seriously degrade the operational suitability of the ATN.[3]

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[1] CANSO Report on CNS /ATM

[2] Except of the Polarregions

[3] IFATCA technical manual section 6 / chapter 5

3. GNSS-1

The GNSS 1 will consist of a number of elements. These will include the navigation satellites, and the ground-based monitoring stations, which, together with communication satellites, will form an Augmentation System. Ground-based differential stations with a datalink may be used at specific locations to augment the system locally. The aircraft will select which elements of the system are to be used depending on the operations to be undertaken.[4][5]

Europe's primary contribution to GNSS-1 will involve signal relay transponders carried on geostationary satellites, and a network of ground stations. Together they are to provide a regional augmentation service for GPS and GLONASS signals over Europe and cover all the countries belonging to the European region. Two Inmarsat-3 satellites will be used, one stationed over the eastern part of the Atlantic Ocean and the other over the Indian Ocean. A third satellite, Artemis, designed by ESA, will be launched in early 2000 and stationed over Africa. This augmentation is called an "overlay", and the European programme is known as the European Geostationary Navigation Overlay Service, or EGNOS.

A monitoring and interpretation service should be established to monitor the status of all elements of the GNSS and interpret this information in a manner that provides relevant information to pilots and ATC. The information disseminated from the monitoring service or displayed at controller positions must be expressed in operational terms.

ATC procedures must be established for the use of GNSS and must cover the failure or degradation of the system. When ATC is informed of a change in the status of the GNSS by the monitoring service or by display equipment, specific procedures associated with that change must be implemented. Should it not be possible to achieve the RNP in an airspace, an alternative RNP should be declared.

4. Area Augmentation Systems

4.1 LAAS/GBAS

Local Area Augmentation System is the ICAO definition ground based augmentation for Satellite Navigation. Ground Based Augmentation System is the European application of LAAS. The time schedule foresees that it could be operational by 2003 including CAT 1 approaches.

4.2 SBAS

SBAS is a generic term for GPS and GLONASS augmentations such as WAAS, EGNOS and MSAS, which use geostationary satellites to broadcast information to users over a large geographical service.

Satellite Based Augmentation System. NATS and other European air traffic service providers (AENA, DFS, ENAV, ANA, Swisscontrol and the Defence Nuclear Agency) have formed the EGNOS Operators and Infrastructure Group (EOIG). SBAS uses the transmission of a GPS look-alike signal from the SBAS geostationary satellite to further augment the GPS system performance. The first full SBAS flight trial was planned for June 1999. EOIG is validating for ICAO the SARPS that define SBAS signal in space performance. SARPS are urgently required to define the SBAS navigation service in adequate detail to prove full interoperability between signals from separately developed systems.

4.2.1 WAAS[6]

There have been a number of proposed systems that could be used to improve the

[4] IFATCA technical manual section 13 / chapter 1
[5] IFATCA technical manual section 13 / chapter 1
[6] IFATCA technical manual Section 8 / Chapter 3

accuracy and integrity of the Global Positioning System (GPS) to enable it to be used for precision approach and landing operations. The USA has decided to develop a system called the Wide Area Augmentation System (WAAS).

The FAA has awarded a contract for the construction of the system. Initial suggestions that it might be available as early as 1997 appear to have been over-optimistic and it is now expected that the system will be fully operational by 2001. This system could be very significant for the future of satellite navigation as it appears that other regions of the world will develop similar, compatible systems that will eventually build up to provide complete world-wide coverage.

WAAS consists of two basic elements. The first is a network of differential ground-stations that receive the GPS signals and calculate differential correction signals. 35 ground stations are required to cover the USA. These differential corrections are then transmitted to the second element of the system, which are WAAS transponders on a number of Inmarsat geostationary communications satellites. The differential signals are then transmitted from the communication satellites to the aircraft. In addition, the communication satellites also transmit integrity information about the performance of the GPS satellites and a signal similar to a GPS satellite. This GPS type signal is used for navigation and gives the appearance of an additional GPS satellite being present.

This situation highlights the importance of the GNSS receiver in the aircraft being able to detect faulty satellites and discard them from the position calculation. The FAA claim that GPS receivers have always detected the failure of a GPS satellite and that an undetected failure has never occurred. The use of WAAS considerably enhances this situation, as it provides a means to independently detect faulty satellite signals and pass this integrity information back to aircraft receivers.[7] (Sic. a kind of a flag in the instrument to show a system failure).

4.2.2 MSAS

Japan is implementing the Multi Satellite-based Augmentation System (MSAS – Japanese Definition) that will provide correction to GPS only. The SBAS system planned by Japan.

4.2.3 EGNOS

The space-borne segment of EGNOS will initially be composed of navigation transponders carried on two satellites owned by the International Maritime Satellite Organisation (Inmarsat). These are Inmarsat-3 series satellites that are positioned above the Indian Ocean at 64° East, and over the Atlantic Ocean at 15.5° West. The Inmarsat-3 satellites operate from geostationary orbits at 36,000km above the Equator. Since their orbit speed matches that of the Earth's rotation, the spacecraft appear to be stationary above the same area of Earth at all times. Inmarsat provides the EGNOS transponder capacity on their two spacecraft under the terms of a lease contract running for five years, with a possible five-year extension. The Inmarsat-3 satellite positioned over the Indian Ocean region was launched in April 1996, while the satellite above the Atlantic Ocean was placed in orbit four months later, in August 1996.

The EGNOS ground network will provide the backbone for three navigation services: ranging, integrity monitoring and wide-area differential corrections.

<u>The ranging service</u> will enable the EGNOS transponders to broadcast GPS-like navigation signals. As a result, these satellites become two more sources of space-based navigation data for users. This is important because neither the GPS or GLONASS systems can guarantee that the minimum number of six satellites required for safety-critical applications, like aircraft navigation, is in view at all times and all locations world-wide. Therefore, EGNOS will help fill this important gap with its navigation signals.

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[7] IFATCA technical manual Section 13 / Chapter 1

The ranging system initially consists of four reference stations (two for each EGNOS transponder), one Mission Control Centre and two navigation uplink stations (one per satellite). The four reference stations perform ranging measurements to determine the precise location of each Inmarsat-3 satellite. This ranging information is then sent to the Mission Control Centre where the satellites' positions are calculated, and synchronisation is performed with respect to the GPS system. The Mission Control Centre then composes a navigation message for the EGNOS transponders. These messages are relayed to the navigation uplink stations for each satellite and transmitted to the spacecraft for re-broadcast as a navigation signal available for users in the coverage area.

Ranging services should be available as the first step under the multi-step introduction of EGNOS, starting early 1998.

The second step in the development of EGNOS is the integrity service; through which range error estimates for each GPS, GLONASS or EGNOS navigation signal are broadcast. The EGNOS integrity service will enable users to know within 10 seconds (or 6 secs?) whether a navigation satellite signal is out of tolerance, allowing action to be taken before any critical situation arises. This is particularly important in applications such as civil aviation landing approaches, where many lives count on the accuracy of satellite signals. Without this integrity service notification of abnormal performance or failure of the various satellites could take 215 minutes or more to reach the users.

The third function of EGNOS is known as the wide-area differential service, which broadcasts correction signals to improve the precision of satellite navigation. With the wide-area differential service, the satellite navigation precision will dramatically increase to 5 or 10 metres – well above the approximately 100 metres for the currently available non-encrypted signals from GPS.

For very specific applications, local area augmentations are required. In this case an interface with EGNOS is foreseen. This also will improve EGNOS coverage in the northern latitudes.

A gradual deployment of EGNOS with adequate redundancies in the number of Control Centres and other system elements is planned. It began with the start of the ranging service early in 1998 (for tests only). The integrity and wide-area differential services is being introduced gradually between 1998 and 2000, allowing EGNOS to reach Advanced Operational Capability in 2001. At this point, it can be used as a primary source of navigation and positioning for such applications as aircraft landing approaches.

This phased service entry for EGNOS was decided to optimise the development effort needed, to minimise technical risks, and provide initial benefits to users as soon as possible.

Full Operational Capability is to be achieved in 2002. At this point EGNOS will have sufficient redundancy to be considered as stand-alone navigation system for the most demanding applications. To this end, EGNOS will be expanded to include EGNOS navigation transponders, navigation uplink stations and Ranging and Integrity Monitoring Stations. [8]

The European Union is also developing the user segment and in particular receivers for all modes of transport. To ensure compatibility of these receivers with those developed in other regions of the world, discussions have begun with ICAO and the International Maritime Organisation IMO.

4.3 ABAS

Aircraft-based augmentation system (ABAS-ICAO definition) augments and/or integrates the information obtained from the GNSS elements with other information available on board the

[8] Note : AOC = Accuracy +Integrity (2003)
FOC = AOC + Availability + Continuity (probably 2006)

aircraft. The aim is to enhance the overall performance of the GPS equipment on board in terms of integrity, (continuity), availability and (accuracy).See chapter A2 CNS/ATM.

5. European Tripartite Group (ETG)

To best manage Europe's contribution to the GNSS, the ETG was formed: it brings together the European Organisation for the Safety of Air Navigation (EUROCONTROL), the European Space Agency (ESA) and the European Commission. Each organisation is contributing with their experience, expertise and funding to the programme.

The ETG's mandate is supported by government decisions at national and European Union level. In particular, the European Union is drafting an Action Programme to set up an institutional and technical framework for the introduction of GNSS for civilian use.

Military use and control over the navigation signals from both the United States' GPS and Russia's GLONASS satellites means there can never be a guarantee that signals from the two systems will always be available on an unrestricted basis, or that a guaranteed level of performance will be maintained. Furthermore, satellites used in the GPS and GLONASS constellations carry a number of non-navigation payloads of considerable military importance. Consequently, it is unlikely that control over these satellites' operations would ever be relinquished by their respective military establishments.

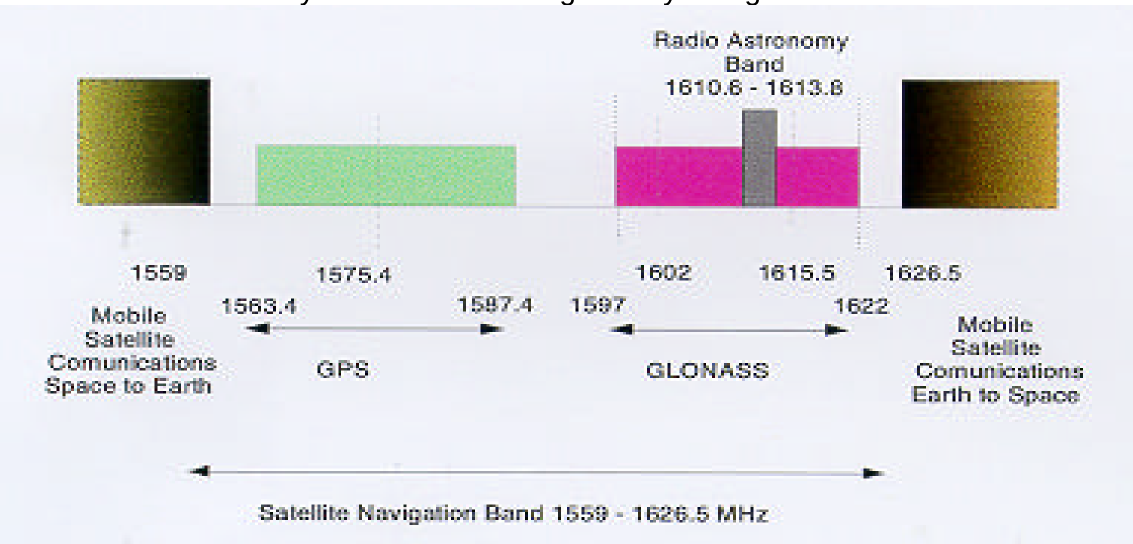
This clearly shows that to make the best and earliest possible use of satellite navigation, a civil successor to GPS and GLONASS must evolve that will not suffer from the technical and institutional limitation of these two current systems.

6. Frequency spectrum

ICAO has stated an intention to move to GNSS as the basis for radio navigation in the 21st century. As discussed, GNSS-1 will be formed from the US GPS and the Russian GLONASS combined with one or more augmentation schemes. To provide the sole means of navigation or even the sole means of radio navigation, GNSS must be protected against interference and states must ensure that no harmful transmissions are present or radiated from their territory. There is a study available carried out by the Eurocontrol Experimental Centre looking at GNSS Frequency Protection requirements (EEC Report No. 337). This study reviews the effect of interference and derives a protection mask for GPS and GLONASS receivers. Protection requirements for the proposed European Navigation Satellite system are also evaluated.

High-powered ground transmitters, such as TV broadcasts, could generate sufficient spurious power to jam a GNSS receiver. However in the en-route phase of flight the aircraft's altitude, combined with reduced antenna gain beneath the azimuth plane and/or distance from the transmitter, provides a large attenuation factor; moreover, such accidental interference is likely to last only for a few minutes, unless deliberate 'jamming' is present. Test flights by UK NATS demonstrated that interference from ground transmitters in some parts of Europe reduced the signal to noise in a GPS receiver, but did not prevent it navigating. Satellite communications in the 1625 MHz band were identified as a problem and precautions taken in the design of the aircraft installation, diplexer and frequency planning to eliminate interference into GPS. Interference into GLONASS is a more difficult problem due to the closer frequency separation. No diplexers are available that are able to remove the out-of-band interference from SATCOM transmissions into GLONASS, but as the system has not yet been installed in western commercial aircraft, the problem does not exist.

Without international co-ordination, the radio spectrum would rapidly become unusable due to incompatible signal formats, strengths and frequencies. Use of the radio spectrum is co-ordinated by the International Telecommunications Union (ITU) through international conferences with the agreements published in the Radio Regulations; however, states are at liberty to make exceptions to the regulations for internal radio services and to transmit on any frequency within their national boundaries. Exceptions are usually registered as footnotes to the regulations; however internal military transmissions are generally unregistered.



Allocations for GNSS and mobile Satellite Communications before 1992

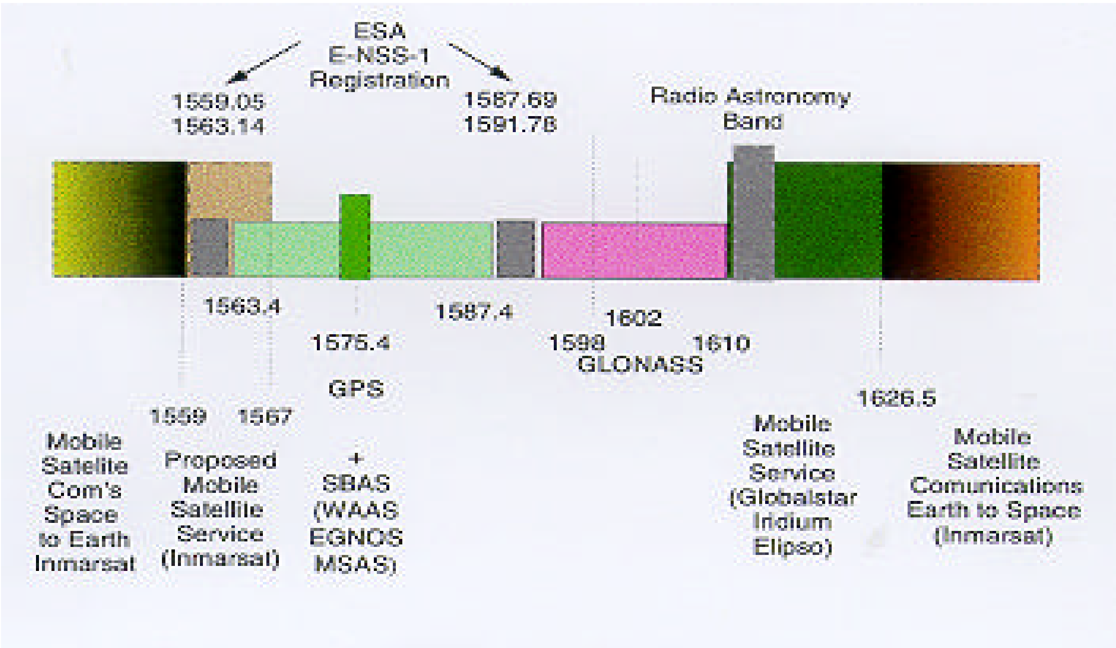


Figure 1-2 *Proposed Frequency Allocations at L-Band*

<u>VHF datalink appear “better than” satellite communications[9]</u>

Switching between ground-based VHF and satellite-derived datalink for CNS/ATM operations can be a seamless procedure, according to tests carried out by the Dutch National Laboratory NLR and ARINC. In general, the ground-based system proved faster and broader than the satellite link. An NLR Cessna Citation III equipped with a EuroTelematik advanced flight management system connect to ARINC’s VHF digital Mode 2 (VDLM2) and satellite communication (SATCOM) networks, made a number of low-altitude flights over the North Sea to test automatic switching of networks needed due to the line-of-sight limitations of VHF.

[9] From Jane's Airport Review, July /August Vol11, Issue 6.

Under test was the end-to-end delivery of Automatic-Dependent-Surveillance (ADS), Controller-Pilot Datalink Communications (CPDLC) and Aeronautical Operational Control (AOC) messages. The trials were attended by the European Commission and Eurocontrol. “Although performance analysis of the different sub-networks was not an objective of the project, it was found the quality of service of VDLM2 was significantly better than SATCOM” according to Eric-Jan Hartlieb, NLR’s Program Manager. “The transfer delay of messages was less than a second for VDLM2, while SATCOM introduced delays of at least 10 seconds. Also the throughput of VDLM2 was significantly better that that of SATCOM. Although no extrapolations for operational use can be made based upon these results, the performance difference was too significant to ignore”.

7. Economic study

The initial costs up to 2001 are estimated at Euro 58.4 million. The overall costs for GNSS I and II will be discussed below in Parts 2 and 3.

B. GNSS-2

1. Technical aspects

Civilian navigation overlay systems are the first step. Not only Europe proposes to advance the civilian use of satellite navigation, moving from the current GPS and GLONASS systems to a next-generation system that meets the needs of the most demanding civil users. Development work on a non-military GNSS has started in Europe, with operational hardware already in orbit.

The service entry of EGNOS and equivalent systems in the US and Japan will certainly not mark the end of the development of satellite navigation systems. Research has already started in Europe on developing technologies for a second generation of satellite navigation systems – which includes satellites, user and ground equipment – the performance of which would meet civilian user requirements.

This new technology would ,for example, lead to a sufficiently accurate, redundant and independent system for use as the sole means of positioning, timing and navigation, including the most demanding applications. Such a future system is known as GNSS-2 or the Second Generation Global Navigation Satellite System. Initial European studies show that there are no unsolvable technical problems that would prevent development of a GNSS-2. GNSS-2 may also integrate other services, potentially even communications links.

The EC and the ESA have both recently launched contracts to study an action plan and to define a possible system architecture for GNSS-2. The studies will examine a variety of operational scenarios that could meet, at the very least, existing civilian operational requirements. Aviation users, for example, are looking for GNSS-2 to be accurate and reliable enough to allow its use as a sole means of navigation for the Category 3B precision approach – which allows landings in conditions of almost zero visibility.

While it is too early to pinpoint all of the future programme’s elements, GNSS-2 will probably need to be a continuation of GPS, GLONASS and EGNOS, combined with regional enhancements that could be provided by a mix of geostationary and nongeostationary satellites (Galileo). In this respect, the installation of navigation payloads onboard the geostationary Inmarsat-3 satellites is considered as a first step towards GNSS-2 (has not yet been decided).

2. Galileo

An all-European satellite navigation constellation took a step closer at the start of May 1999 when government ministers of ESA countries gave a financial commitment to setting up Galileo, a second-generation global navigation satellite system (GNSS-2).

Galileo will be a global navigation satellite system under civil control. It will consist of 21 or more satellites, depending on the level of international co-operation, the associated ground infrastructure and regional / local augmentations. GalileoSat is the complementary development initiative of the ESA for the space and the associated ground control segments.

Galileo will be used in all modes of transportation for navigation, traffic and fleet management, tracking, surveillance and emergency systems. As such, Galileo will be a key element of the future inter-mode traffic management system. Moreover it has many non-transport applications.

The system will involve a space segment of around at least 21 medium earth orbit (MEO) satellites, plus three geostationary earth orbit (GEO) satellites and will cost Euro 2.2 – 2.95 billion to develop. (There are system proposals for up to 40 MEO satellites).

Taking the current planning, Galileo will be fully operable in 2008 at the latest, with the start of signal transmission in 2005.

Galileo and GPS will be interoperable and compatible. International Partners will be involved actively in the Galileo programme.

3. Economic Study

Macro-economic benefits totalling Euro 90 billion will be created through additional equipment, sales and services during the service introduction and the first 15 years of operation. In these industries, Galileo will create more than 100 000 new jobs. Potential wider benefits result from the use of the system.

GNSS-1 replacement is also an important market: the satellites making up GNSS-1 – Inmarsat-3, GPS and GLONASS in the short term – will need to be replaced beyond the years 2003 –2005 and then renewed approximately every 10 years. This represents a significant potential market for Europe’s space industry if it were in a position to become a procurement source for these replacements. As an indication of the potential business opportunities, the estimated cost of a full navigation constellation of, for example 16 satellites, is Euro 650 million, plus an annual turnover of Euro 70 million for the renewal of obsolete satellites.

The ground-based infrastructure needed to support the operational civil requirements also provides a considerable market, with its total value probably in excess of the cost of the satellites themselves.

C. A short description of ADS

1. ADS[10]

ICAOs FANS (Future Air Navigation Systems) committee addressed the problem of the shortage of capacity in the ATC system in a number of ways. One of the concepts, that forms the foundation of the ICAO CNS/ATM concept, is ADS or Automatic Dependent Surveillance.

One of the major capacity shortfalls in the ATC service provided in some parts of the globe, is the use of procedural control. Non-radar separation standards are necessarily large to accommodate the lack of continuous updates of flight data to the controller and thereby to accommodate the safety of aircraft under control. Additionally a fixed route structure is often linked to operations in such areas where non-radar control is employed. This provides the structure and predictability with which traffic can be controlled and the certainty or predictability necessary for control to be exercised. It is, in effect, a snapshot of time approach to ATC and therefore it is always historic.

Non-radar control is the only type of control possible in some parts of the globe – over the high seas, or in sparsely populated areas , because it is not possible to provide an ATC infrastructure that can support radar and communication systems. The results of this type of operation incur penalties to aircraft operators, especially as in some areas the aircraft operating in these areas have long sector lengths, thus the cost of non-optimal flight is high. For example, in 1992 United Airlines estimated that it would save US$238,000 per month, per aircraft, flying on North Pacific routes by flying user preferred routes utilising ADS and GNSS. Therefore, to increase capacity in these types of operating environments, the limitations of the line of sight restrictions of radar and VHF voice communications must be overcome to provide a more flexible and efficient ATC service.

The FANS committee sought to use a number of emergent technologies that have reached a mature stage in their development to address these problems.

ADS: - The Concept

The most notable enabling technology is the use of satellites, in two forms –communications (or SATCOM) and satellite navigation (or SATNAV). It is important to distinguish between the two. Other technologies that will be employed will be the use of digital data communications and networks, on a global scale - the ATN or Aeronautical Telecommunication Network. This uses protocols and an architecture that is able to meld data in an operable way through several levels or 'layers'. Airlines are already well advanced in utilising digital data communications datalink such as AIRCOM, ACARS, and AVPAC, based upon ARINC 622 and 722 protocols.

" ADS is a service for use by air traffic services in which aircraft automatically provide, via a datalink, data derived from on board navigation and position fixing systems." One way of considering ADS is to think of it in terms of a communications system. The aircraft communicates its position, derived from on board systems, to ATC automatically. That is all that ADS is. It is automatic because position reports and other routine messages are transmitted automatically by equipment on board the aircraft. The rates at which these are sent is established prior to entry into ADS airspace, by forming a contract between the ATSU and the aircraft. If the ATSU wants a report at a different interval then this can be obtained. It is dependent because the position of an aircraft that is presented to ATC is derived solely from aircraft on board systems. There is no independent determination or corroboration of the aircraft's position, such as radar provides, carried out by ATC.

[10] IFATCA technical manual Section 8 / Chapter 1

To turn ADS into an operable system it requires a lot more than just the communications links. It needs a system: or ADS-ATC system components. An ADS-ATC system is purely an ATC system that uses ADS, wholly or in part as its surveillance medium.

It is important to understand that the way that FANS and the CNS/ATM has evolved is such as to give a 'menu' of tools with which to mix and match systems to suit the operational requirements of particular ATS providers. However, given the flexible approach that the FANS committee developed, there is still a basic level of system components that will be required for operational use. Therefore the composition of an ADS-ATC system might take the form depicted and described in Section F.

D. IFATCA policy[11]

When any failure to the GNSS occurs, it is to be expected that some aircraft will fail to meet the RNP (Required Navigation Performance) and require special action to be taken, while others will be able to continue to meet the RNP. It is important that controllers and pilots are made aware of any degradation in a timely manner.

IFATCA policy is:
"A monitoring and interpretation service should be established to monitor the status of all elements of the GNSS and interpret this information in a manner that provides relevant information to pilots and ATC. The information disseminated from the monitoring service or displayed at controllers' positions must be expressed in operational terms. ATC procedures must be established for the use of GNSS and must cover the failure or degradation of the system. When ATC is informed of a change in the status of the GNSS by the monitoring service or by display equipment, specific procedures associated with that change must be implemented. Should it not be possible to achieve the RNP in an airspace, an alternative RNP should be declared."

IFATCA requires that the safety, integrity, and reliability of GNSS be guaranteed before GNSS achieves a “sole means” status of navigation. One important benefit of CNS is the declaration that GNSS becomes the “sole means” of navigation and communication, which will make the terrestrial navaids obsolete. Therefore, many of the existing ground aids could be removed eradicating the major cost of their maintenance and replacement.

E. References

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GNSS	by the European GNSS Office
EEC 337	Report of the GNSS Frequency Protection requirements by the Eurocontrol Experimental Centre EEC
Jane’s	Airport Review July/August 1999 Vol 11, Issue 6
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Policy	IFATCA Manual, IFATCA Technical manual
JAA	Position Paper on Navigation Augmentation Systems, 19.7.99, pp 008_4a
CANSO	Report prepared by CNS/ATM Working Group Final Version June 99

[11] IFATCA Manual 32110 and Vision Document

F. Schematic presentation